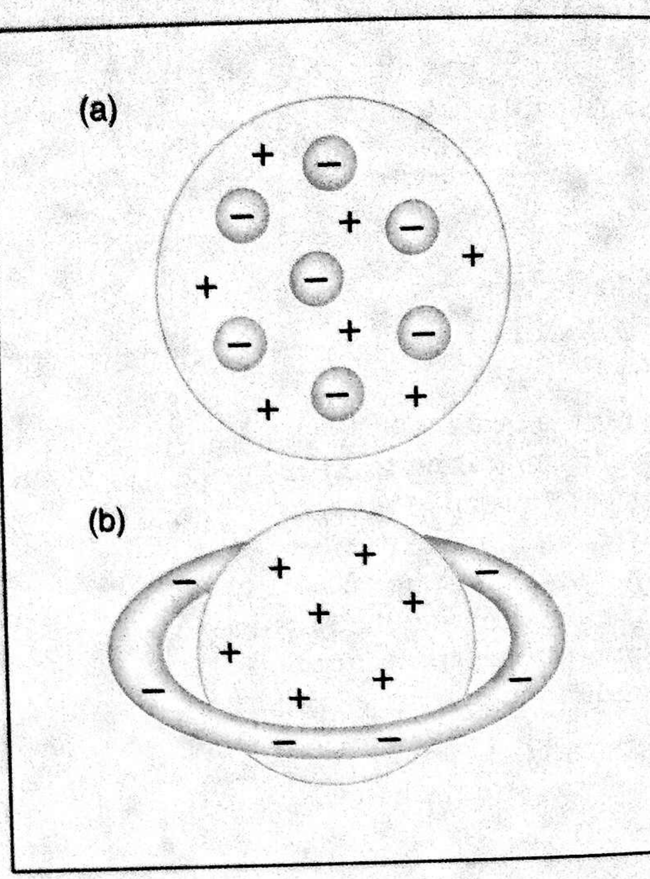
Chem Talk

THE CHANGING MODEL OF AN ATOM

J.J. Thomson's Model of an Atom



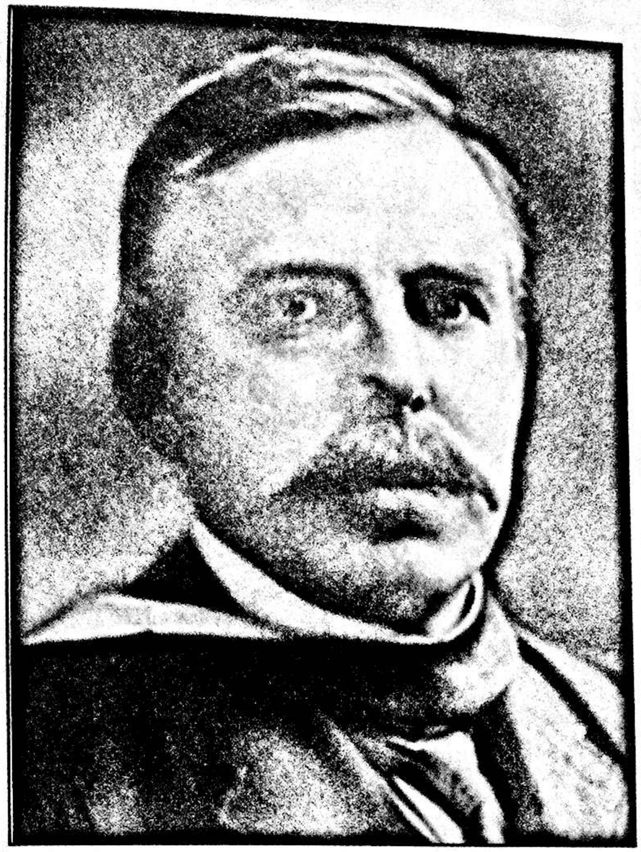
As you noted in this activity, in the late 1800s J.J. Thomson, an English physicist, found evidence for the existence of negatively charged particles that could be removed from atoms. He called these subatomic particles with a negative charge **electrons.** Using this new information, Thomson then proposed a model of an atom that was a positive sphere, with electrons evenly distributed and embedded in it, as shown in the diagram. Using the same evidence, H. Nagaoka, a Japanese scientist, modeled the atom as a large positively charged sphere surrounded by a ring of negative electrons.

Chem Words

electron: a subatomic particle that occurs outside of the nucleus and has a charge of –1 and mass of 9.109×10^{-28}g.

Rutherford's Discovery of the Nucleus

For several years there was no evidence to contradict either Thomson's or Nagaoka's atomic models. However, in the early 1900s, Ernest Rutherford, a New Zealand-born scientist, designed experiments to test the current model of an atom. In Rutherford's experiment, alpha particles were sent as "missiles" toward a thin sheet of gold. Gold was used because it is malleable and could be hammered into a thin, thin sheet. Most of the alpha particles went through the sheet and were not deflected. It is as if they missed the target. This was expected since it was assumed that the atom's charge and mass



Ernest Rutherford

was spread evenly throughout the gold. Occasionally one of the alpha particles that "hit" the gold sheet bounced back. This was the big surprise. The conclusion: there must be tiny places containing lots of charge and mass. Since the bouncing back was so unusual, it was assumed that the places where all the charge and mass were concentrated were only 1/100,000 of the area of the gold. Rutherford concluded that almost all the mass and all of the positive charge of the atom is concentrated in an extremely small part at the center, which he called the **nucleus**. He also coined the term **proton** to name the smallest unit of positive charge in the nucleus.

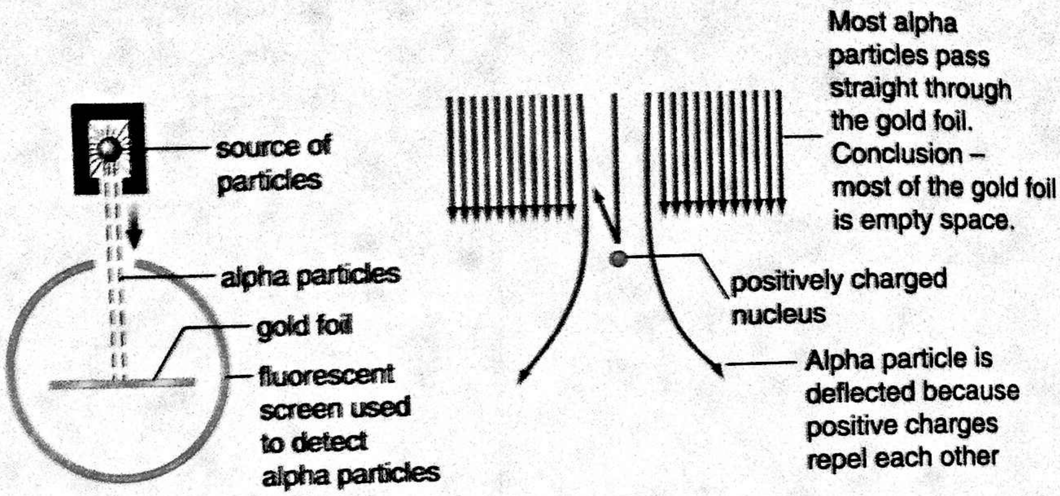
Chem Words

nucleus: the very dense core of the atom that contains the neutrons and protons.

proton: a positively charged subatomic particle contained in the nucleus of an atom. The mass of a proton is 1.673×10^{-24}g and it has a charge of +1.

The story of Rutherford's discovery of the atomic nucleus is best told by Rutherford himself. Examining the deflection of high-speed alpha particles as they passed through sheets of gold foil, Rutherford and his student Hans Geiger noticed that some particles were scattered through larger angles than predicted by the existing theory of atomic structure. Fascinated, Rutherford asked Geiger's research student Ernest Marsden to search for more large-angle alpha scattering. Rutherford did not think that any of the alpha particles in his experiment would actually bounce backward. "Then I remember two or three days later Geiger coming to me in great excitement and saying, 'We have been able to get some of the alpha particles coming backwards . . .' It was quite the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you."

RUTHERFORD'S EXPERIMENT



Experimental setup

Observed results

Checking Up

1. What is an electron?
2. Thomson's model of an atom is sometimes referred to as the "plum-pudding" model. (A plum pudding is a heavy pudding with raisins mixed into it.) Explain why this is an appropriate comparison.
3. Why was Rutherford surprised that some alpha particles bounced back from the gold foil?
4. What is the nucleus of an atom?

A Physics Connection

What was responsible for the wide-angle scattering of the alpha particles and their bouncing back? The force between the positive nucleus and the positive alpha particle is the coulomb force. Positive charges repel one another according to the coulomb force law.

$$F = \frac{kq_1q_2}{d^2}$$

where k is Coulomb's constant
($k = 9.0 \times 10^9$ N m^2/C^2),
q is the charge in coulombs, and
d is the distance between the charges.

The closer the alpha particle gets to the nucleus, the larger the force and the larger the deflection of the alpha particle.